measuring a second position-dependent, energy-dependent intensity profile of the

x-ray beam at the detector array immediately after the beam has been transmitted through

the patient, and

comparing the first and the second position-dependent, energy-dependent

intensity profiles of the beam.

REMARKS

In the office action post marked April 21, 2004 the Examiner rejected claim 57 based on Yarnall, claim 58 based on Yarnall and Dhawale, and claim 59 based on Hsieh and Possin.

Applicants will address first the rejection of claim 57 as being anticipated by Yarnall. Yarnall describes how to determine optimal positioning of a single detector, hand held probe in terms of avoiding inadequate count statistics or pulse pileup (signal rate exceeding recovery time of the detector). See col.8: lines 37-67, col. 9: lines 1-19, col. 10: lines 42-54. This calibration procedure uses audi and/or visual feedback "cues" to help the technician position the detector probe.

Applicants (p. 44: lines 20-24, p.45: lines 1-6) describe the use of a known source distribution so that a detector module array can be calibrated electronically and that the responses of detector modules can be balanced through hardware or software. The calibration effort also includes events (such as scattered photons) that are recorded in more than one detector module. Thus the relative position of detector modules enters into the calibration effort. Calibration could be significantly different for modules near the perimeter of the detector array vs. a module with nearest-neighbors on all sides. And this calibration effect will be present for various detector geometries (focused, ring, parallel plane, box, plane, slit, slot) and source energies (whether x-ray or gamma ray sources). Applicants maintain that they are describing a method of calibrating an imaging system using multiple detector modules, including any interactions between detector modules within the system. Applicants contend that their method is distinctly different from the approach described by Yarnall.

Applicants will address the rejection of claim 58 as being anticipated by Yarnall and Dhawale. Yarnall describes the use of a detector with energy resolution. However, it is a single detector and so there is no concern with MTF at all. Dhawale, on the other hand, describes a fluorescopic imaging chain and an adaptive noise reduction algorithm to improve image contrast by reducing noise. His fluoroscopic x-ray detector component 15 (Figure 1) is described as a digital flat-panel x-ray detector or an image intensifier (basically a planar 2-D detector that operates at video rates of 15-30 frames per second

3

(Col. 3: lines 8-25). This detector has essentially no energy resolution. Dhawale talks about storing the x-ray spectrum in a file which will then be used in the FNR algorithm for noise reduction (Col. 6: lines 3-32). This is well-understood in the trade since the spectrum is typically adjusted for best contrast with acceptable patient dose during a fluoroscopic examination. Dhawale discusses using the MTF of the detector (Col. 8: lines 47-49) to modify the image, another "known" quantity. Since the detector has no energy resolution, at best the MTF is only known for a given x-ray tube voltage (crudely) and thus a broad spectral distribution. If the detector is an image intensifier then the MTF varies with radial position with respect to the center! What Dhawale has discussed is well-known in the trade for x-ray fluoroscopy. What Dhawale is not addressing is the fact that the beam spectrum and the intensity are not uniform across the detector area even when a non-uniform filter (the patient) is not present. Dhawale takes one broad spectral distribution of the x-ray beam and then uses it as an input for his FNR algorithm. The same spectral distribution is assumed (prior to patient filtration) to be seen by all detector pixels. Dhawale does not anticipate a need for MTF(E). Furthermore, Dhawale's is not doing energy calibration but rather energy compensation. He is simply attempting to account for the filters placed in the beam path that is assumed (incorrectly) to be uniform everywhere.

Applicants (p. 45: lines 6-24, p.46: lines 1-24, p. 47: lines 1-6) describe calibrating the detector by determining MTF(E) and determining the intensity of the spectral distribution of the x-ray source beam, which need not be uniform across the detector. Then spatially-dependent corrections can be made concerning the energy-dependent filtration of the x-ray beam since we know the intensity of the spectral content of the beam at each detector pixel before and while the patient is imaged. A detector with energy resolution can be used to correct the spatial image as a function of E (MTF(E1), MTF(E2), etc.). This could be highly beneficial for high contrast applications such as mammography, when contrast material is present, or dual energy (triple energy, etc.) imaging. The problem is not just that the intensity of the x-ray beam decreases away from the center, the spectral distribution or content also changes!

Applicants will address the rejection of claim 59 as being anticipated by Hsieh and Possin. Hsieh (Col. 2: lines 53-56) describes a method to correct projection profile data due to variations in z-axis (axis of rotation) detector sensitivity and z-axis x-ray flux gradients due to the presence of the scanned patient. The symbol "E" refers to an error vector and not energy. Attenuation data is acquired during a calibration scan of a phantom (Col. 2: lines 44-46) in order to determine a calibration vector Q to correct for beam attenuation along the z-axis. Hsieh does not describe the detector array (18) as having energy-resolving capability. In fact, one purpose of the x-ray beam filters that precede the patient is to both remove low energy x-rays (reducing the value of energy resolution). The other purpose is to reduce the range of intensity values that the individual detector elements will see (Col. 4, lines 8-19). So the filters would reduce the value of a detector with energy resolution! The reference channels (20) are to correct for the time-varying x-ray flux output from the x-ray tube (Col. 4, lines 26-33). Hsieh talks about measuring intensity profiles and not energy profiles. In Claim 1 Hsieh refers to measuring a set of attenuation signals that indicate the x-ray flux density profile, not the

4

energy intensity profile. Possin describes an edge-on detector in which the scintillator is optically-coupled to an array of photosensors. The scintillator is preferably a fiber optic and the photosensor is preferably a thin film deposited photosensor. Possin describes the device as being useful for high resolution CT scans and high energy radiography. Possin's MTF values are for a given x-ray beam voltage. Possin does not describe a MTF that explicitly depends on energy E. In fact his design results in a detector with rather poor energy resolution since it purports to use fiber optic scintillators (cheap but low signal output) and photodiodes as readout (normally used as signal integrators that are intended to measure total signal strength for a given integration time, not spectroscopy). Thus, Possin's design might be used for specialized CT applications, which does not benefit significantly from energy resolution as we learned from Hsieh. Attributes of Possin's design include relatively high spatial resolution at relatively high x-ray energies (good stopping power) but not good energy resolution.

Applicants do not use (or need to use) a phantom to calibrate the x-ray source as Hsieh does. Rather the energy-dependent intensity as a function of position is measured without a patient and then is measured with the patient. This allows the detection system with energy resolution to determine what fraction of photons of energy E were attenuated by the patient path before reaching the detector. Thus our calibration effort is entirely different than that of Hsieh who is only concerned with the intensity profiles. Possin has designed a detector with inherently poor energy resolution. Neither Possin or Hsieh attempt to address the issues that Applicants are concerned with (analyzing position-dependent and energy-dependent attenuation within the patient, calibrating multiple detectors that provide spatial and energy resolution).

CONCLUSION

Applicants respectfully submit that all of the Examiner's rejections have been overcome. Applicants respectfully request that the Examiner reconsider and withdraw the outstanding rejections and allow the present application. Applicants invite the Examiner to telephone the undersigned representative if the Examiner believes that a telephonic interview would advance this case to allowance.

Respectfully submitted,

By: _Robert Sigurd Nelson_   Dated: _5-14-04_
    Robert Sigurd Nelson

Robert Sigurd Nelson
2922 Upshur Street
San Diego, California 92106
Phone (work): (619) 594-1013.
Fax (work): (619) 594-5485.
Fax (home): (619) 222-1720